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Ecosystem Evolution and Ecological Storage On Surface Coal Mine

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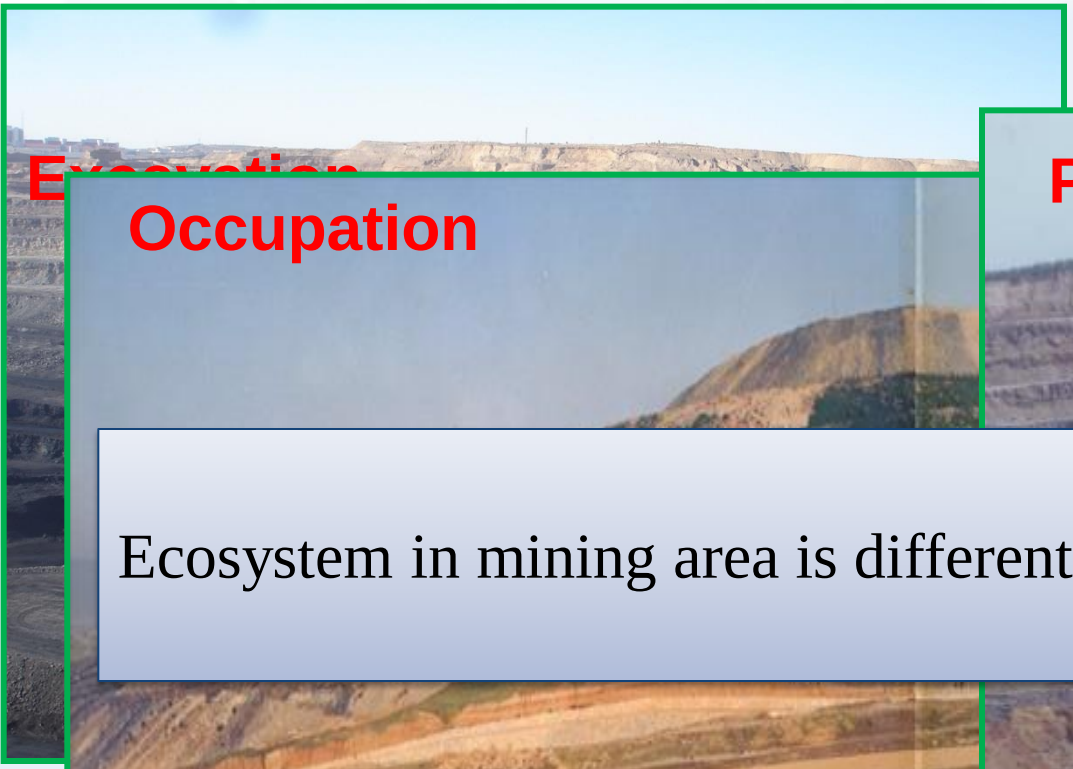
Research question

Opencast mining area is greatly disturbed by human activities. Large scale mineral resource exploitation has destroyed the natural ecosystem in mining area by damaging soil and plants, changing hydrothermal structure, and polluting environment.



Excavation

Occupation

Pollution

Ecosystem in mining area is different from natural environment.

Research Review

Contents

- Functions and benefits
- Evolution and evaluation
- Simulation and design
- Degradation and restoration

Scale

- Macroscopic scale：region or landscape
- Microcosmic scale：micro-ecosystem

Methods

- Traditional experimentation
- Mathematic models
- RS & GIS

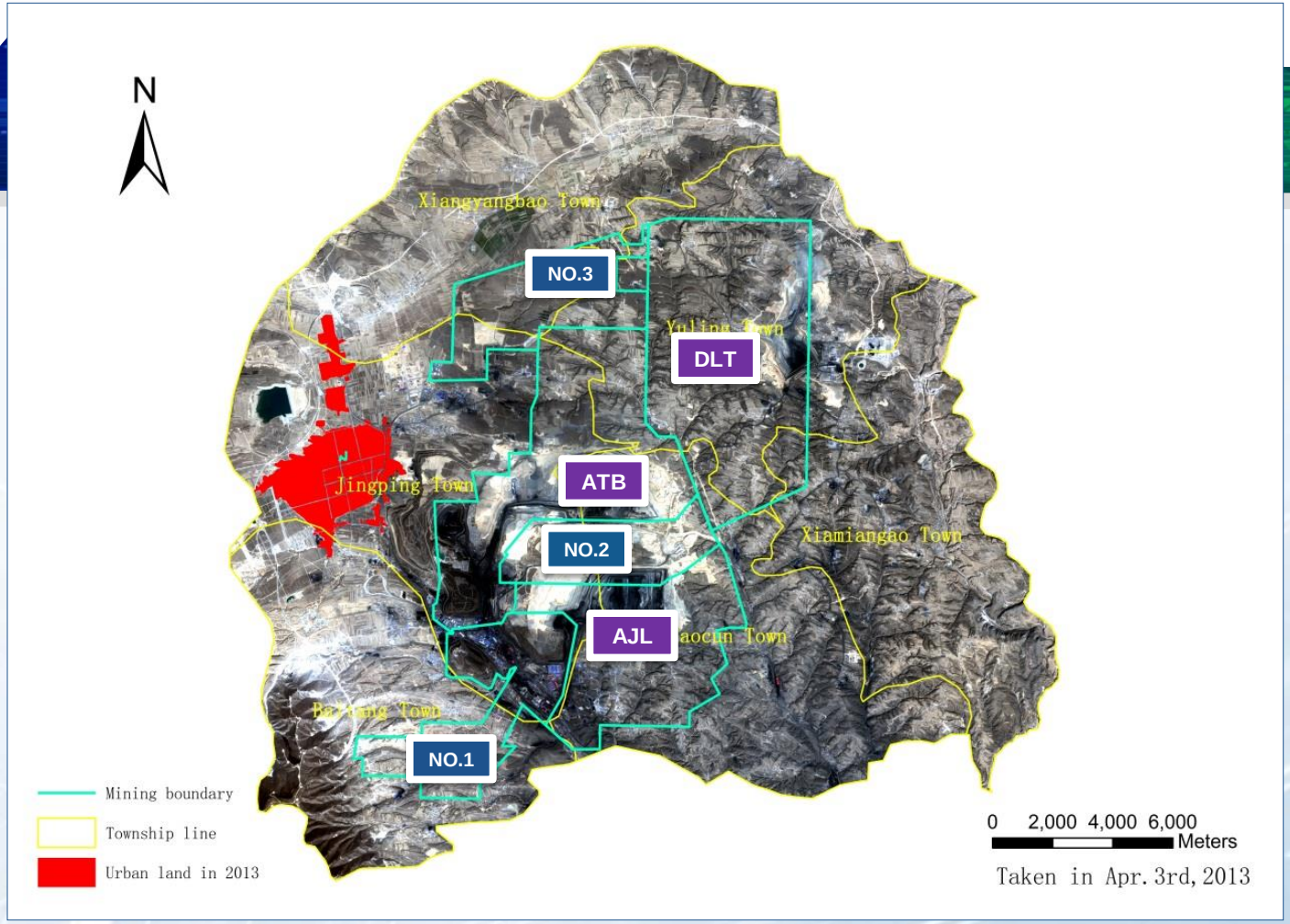
The study goals:

- To analyze ecosystem evolution of a outsize opencast coal mine
- To evaluate ecological level with ecological storage model

General situation of study area

Pingshuo mining area is located in:

- Pinglu District, Shuozhou City, Shanxi Province
- the east of Loess Plateau
- the north of Ningwu Co
- 111° 58′ E-112° 30′ E,



- The total area of Pingshuo mining area is around 517 km^2, and the proven coal reserves are 12.75 billion tons.
- There are three surface mines, three underground mines, two coal washeries and two dedicated railways.
- Pingshuo is the largest coal mine with the highest modern equipment in China.

Data resources and processing

Remote sensing images

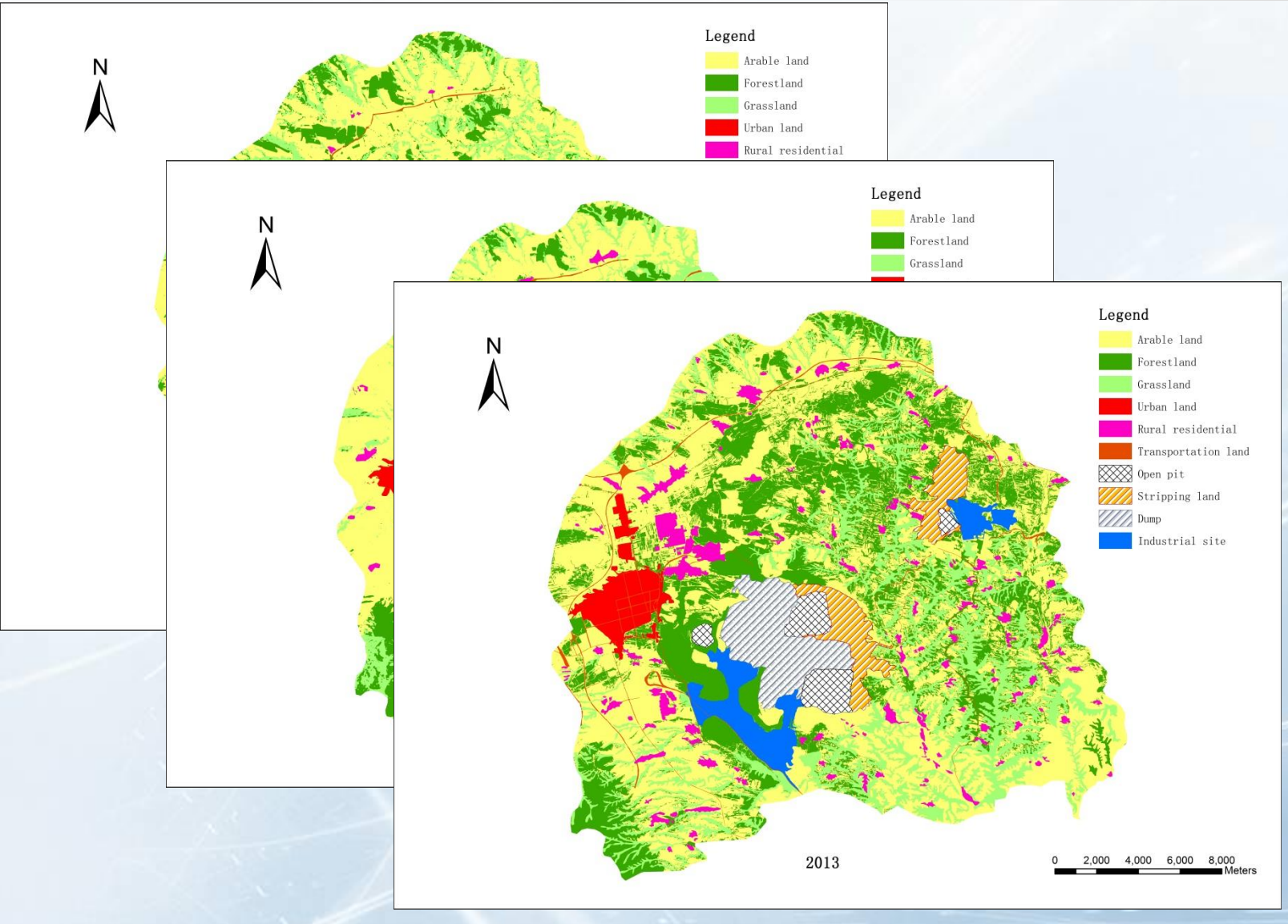
Number	Satellite (sensor)	Date	Spatial resolution
1	Landsat5 (TM)	1986-06-20	30 m
2	Landsat5 (TM)	2000-05-22	30 m
3	SPOT6 (Reference 3D)	2013-04-03	6m

- Images processing software: ENVI 4.8
- Preprocessing: atmospheric radiometric correction, geometric correction, images clipping
- Classification method: Artificial Neural Net, visual interpretation

Land use types:

Arable land, grassland, forestland
Urban land, rural residential, transportation land
Open pit, dump, stripping land, industrial site

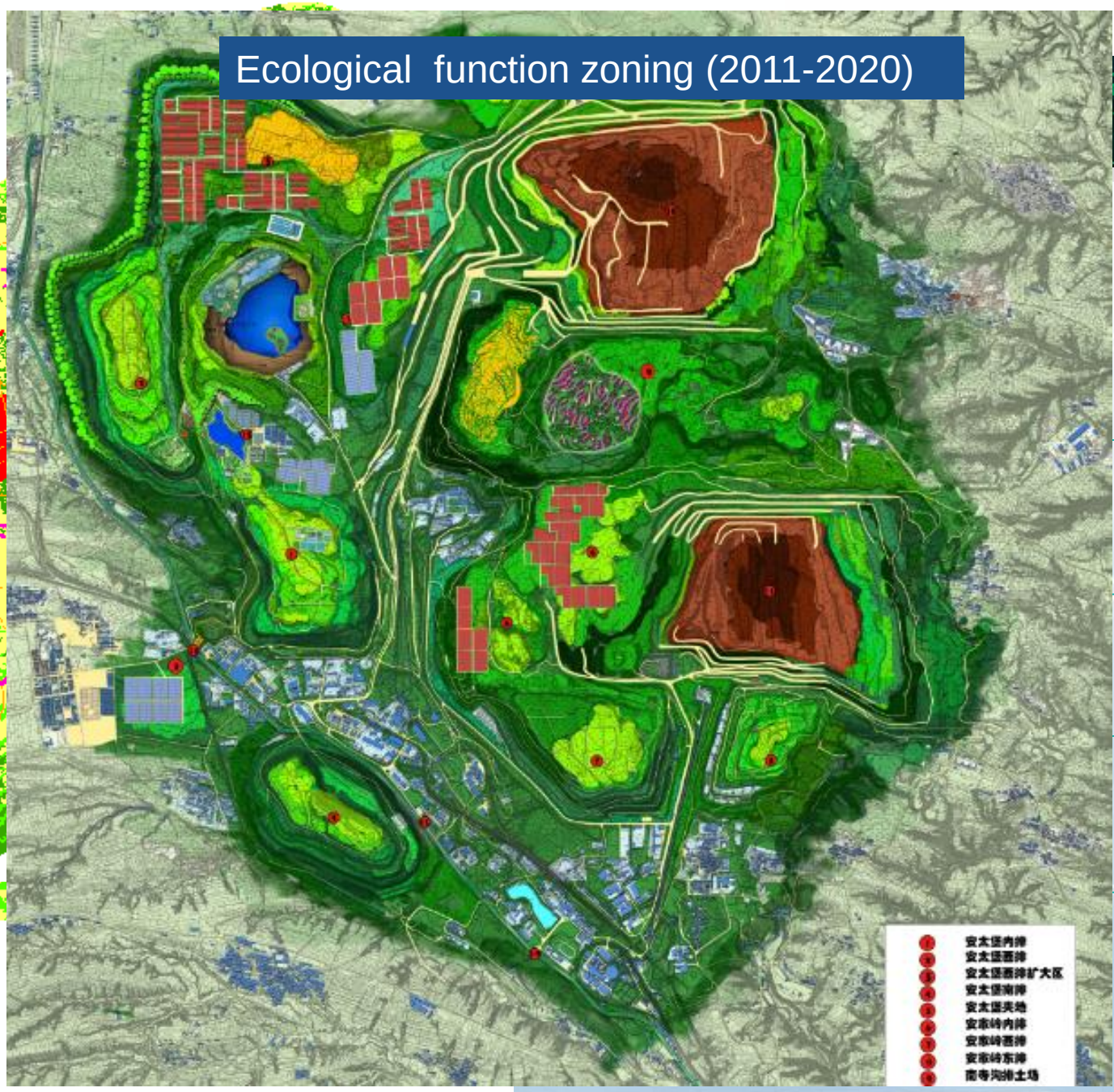
Land use changes in the study area



Land use changes in the study area

Land use type	1986	2000	2013
Arable land	32119.68	26746.18	21661.35
Forestland	8426.73	6239.54	6126.76
Grassland	10655.54	14840.15	14216.94
Urban land	174.21	611.07	1168.12
Rural residential	157.04	786.29	2019.39
Transportation land	214.85	399.00	463.85
Open pit	0.00	535.08	992.07
Stripping land	0.00	592.59	1461.64
Dump	0.00	594.26	1980.70
Industrial site	0.00	403.89	1657.23

Ecological function zoning (2011-2020)



Ecosystem evolution in the study area

Spatial evolution

- Land use classification is based on the difference of land units functions, which can match to the classification of terrestrial ecosystem.

Ecosystem types	Land-use types	Ecological functions
Farmland ecosystem	Arable land	Mainly providing food
Forestland ecosystem	Forestland	Climate regulation, water conservation, air purification, water and soil preservation, wind prevention and sand fixation, smoke prevention, hydrothermal change
Grassland ecosystem	Grassland	Water conservation, soil, climate and biodiversity regulation
Urban ecosystem	Urban land, rural residential, transportation land	Biodiversity circulation, water waste, exhaust gas and soil waste production
Industrial ecosystem	Open pit, stripping land, dump, industrial site	Biodiversity circulation, water waste, exhaust gas and soil waste production

Ecosystem evolution in the study area

Land use transfer matrixes of each sub-ecosystem in the study area in 1986-2000 and 2000-2013 (ha)

1986-2000	Farmland ecosystem	Forestland ecosystem	Grassland ecosystem	Urban ecosystem	Industrial ecosystem	Total
Farmland ec						
Fo ec						
Gr ec						
U ec						
In ec						

2000-2013	Farmland ecosystem	Forestland ecosystem	Grassland ecosystem	Urban ecosystem	Industrial ecosystem	Total
Farmland ecosystem	21406.41	0.00	0.00	0.00	254.94	21661.35
Forestland ecosystem	704.07	4639.87	202.32	196.02	384.48	6126.76
Grassland ecosystem	981.05	207.66	12922.90	0.00	105.33	14216.94
Urban ecosystem	1290.67	125.71	634.64	1600.34	0.00	3651.36
Industrial ecosystem	2363.98	1266.30	1080.29	0.00	1381.07	6091.64
Total	26746.18	6239.54	14840.15	1796.36	2125.82	51748.05

Conclusion 1

There is a close relationship between ecosystem evolution and land use changes, and the latter can represent the process and features of the former.

Ecological storage model

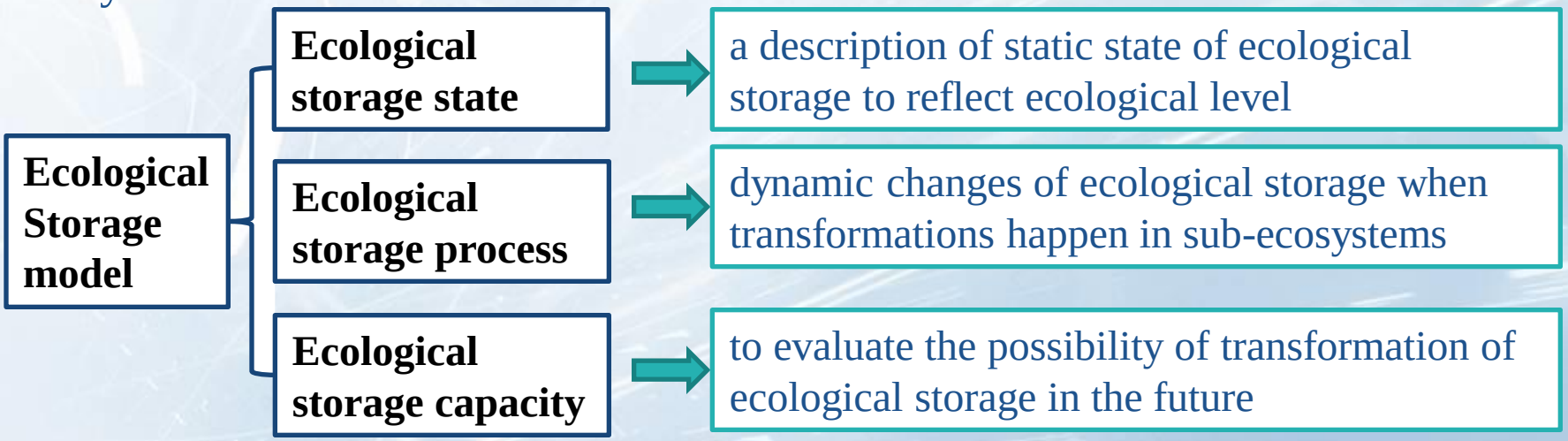
Ecological storage

is defined as an integrated expression ecological changes caused by land use quantity, quality, types and distribution from the past, present and future activities by nature and human. (Zhang et al., 2010)

Theoretical basis:

Ecosystem service values proposed by Costanza et al.

Researches of terrestrial ecosystem service value in China conducted by Xie et al.



Ecological storage model

Ecological Storage State

$$ESS = \frac{\sum_{i=1}^{n}(VC_i \times A_i)}{\sum_{i=1}^{n} A_i} \times N_y$$

Ecological Storage Process

$$ESTA = \sum_{i=1,j=1}^{m,n}(VC_j - VC_i)A_{i\to j}$$

$$ESTR = \frac{\sum_{i=1,j=1}^{m,n}(VC_j - VC_i)A_{i\to j}}{|ESS_0|}$$

Ecological Storage Capacity

$$ESC = \frac{1}{\sum_{i=1}^{n} a_i} \times P \times T^T$$

$$P = [p_1, p_2, ..., p_n] = \left[\frac{a_1}{\sum_{i=1}^{n} a_i}, \frac{a_2}{\sum_{i=1}^{n} a_i}, ..., \frac{a_n}{\sum_{i=1}^{n} a_i}\right], \sum_{i=1}^{n} p_i = 1$$

$$T_{1\times n} = \left[\frac{1}{n_1}\sum_{i=1}^{m} vc_{1i} \times a_1, \frac{1}{n_2}\sum_{i=1}^{m} vc_{2i} \times a_2, ..., \frac{1}{n_n}\sum_{i=1}^{m} vc_{ni} \times a_n\right]$$

A refers to the area of land use type;
VC refers to the ecosystem service value of land use type;
P is the matrix composed by the ratios of the area of each sub-ecosystem to the total area;
T is the average of extreme ecological service value of all transformation.

Ecological storage in the study area

Ecosystem service value of unite area in Pingshuo mining area (RMB/ha)

	Farmland ecosystem	Forestland ecosystem	Grassland ecosystem	Urban ecosystem	Industrial ecosystem
Gas regulation	442.4	3097	707.9	-1380.3	-48.4
Climate regulation	787.5	2389.1	796.4	0	0
Water conservation	530.9	2831.5	707.9	-14542.6	-1919.1
Soil formation and protection	1291.9	3450.9	1725.5	0	0
Waste treatment	1451.2	1159.2	1159.2	-10128.6	-93.8
Biodiversity conservation	628.2	2884.6	964.5	300.8	300.8
Food production	884.9	88.5	265.5	0	0
Raw material	88.5	2300.6	44.2	0	0
Entertainment culture	8.8	1132.6	35.4	0	0
Total	6114.3	19334.0	6406.5	-25750.7	-1760.5
Coefficient modification	2812.578	8893.64	2946.99	-11845.322	-809.83

Ecological storage in the study area

Ecological storage state (10^4RMB)		1986	2000	2013
		0.3676	0.2927	0.2109
Ecological storage process		1986-2000		2000-2013
	Conversion quantity of ecological storage (10^4RMB)	-0.3876		-0.4233
	Conversion percent of ecological storage (%)	-105.46		-144.62
Ecological storage capacity (10^4RMB)		1986-2000		2000-2013
		-0.1577		-0.1145

- The ecological storage amount decreased ;
- The amount and the rate in two periods are negative:
  converse ecosystem transformation during 1986-2013
  positive transformation is less than negative transformation
- Negative values: ecological storage is in a passive situation.
- The value becomes greater: ecological storage capacity becomes better.
- Positive human intervention has strengthened ecological storage capacity.

Conclusion 2

The ecological storage state deteriorated, and the ecological storage transformation presented a reverse process; however, the ecological storage capacity became better.

Ecological storage in different scenarios

No mineral exploitation in the study area

Original land use structure
Population growth----Urban expansion----
Deteriorated ecological storage

Mineral exploitation without land reclamatio

By 2013, the total area of reclamation land in Pinshuo
1672.32 ha, which can produce 346 RMB ecological s

Mineral exploitation with efficient land reclan

After efficient land reclamation, the ecosystem becom
balanced structure. Ecological storage of rebuilt ecosy
original ecosystem.

Conclusion 3

Effective land reclamation can improve the ecological state greatly.

Thanks for your attention!